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# Development and validation of a score to assess risk of medication errors detected during medication reconciliation process at admission in internal medicine unit: SCOREM study

Yohan Audurier<sup>1</sup> | Camille Roubille<sup>2,3</sup> | Federico Manna<sup>4</sup> | Laetitia Zerkowski<sup>2</sup> | Marie Faucanie<sup>4</sup> | Valérie Macioce<sup>4</sup> | Audrey Castet-Nicolas<sup>1,5</sup> | Anne Jalabert<sup>1</sup> | Maxime Villiet<sup>1</sup> | Pierre Fesler<sup>2,3</sup> | Laura Lohan-Descamps<sup>1,3</sup> | Cyril Breuker<sup>1,3</sup>

<sup>1</sup>Clinical Pharmacy Department, University Hospital, Montpellier, France

<sup>2</sup>Department of Internal Medicine and Hypertension, Montpellier University Hospital, Montpellier, France

<sup>3</sup>PhyMedExp, University of Montpellier, INSERM U1046, CNRS UMR 9214, Montpellier, France

<sup>4</sup>Clinical Research and Epidemiology Unit, University Hospital, Montpellier, France

<sup>5</sup>IRCM-INSERM U1194, University of Montpellier, Montpellier, France

## Correspondence

Cyril Breuker, Clinical Pharmacy Department, University Hospital, Montpellier, 191 avenue du doyen Gaston Giraud, 34295 Montpellier, France. Email: c-breuker@chu-montpellier.fr

## Abstract

**Background:** Medication errors (ME) can be reduced through preventive strategies such as medication reconciliation. Such strategies are often limited by human resources and need targeting high risk patients.

**Aims:** To develop a score to identify patients at risk of ME detected during medication reconciliation in a specific population from internal medicine unit.

**Methods:** Prospective observational study conducted in an internal medicine unit of a French University Hospital from 2012 to 2016. Adult hospitalised patients were eligible for inclusion. Medication reconciliation was conducted by a pharmacist and consisted in comparing medication history with admission prescription to identify MEs. Risk factors of MEs were analysed using multivariate stepwise logistic regression model. A risk score was constructed using the split-sample approach. The split was done at random (using a fixed seed) to define a development data set (N = 1256) and a validation sample (N = 628). A regression coefficient-base scoring system was used adopting the beta-Sullivan approach (Sullivan's scoring).

**Results:** Pharmacists detected 740 MEs in 368/1884 (19.5%) patients related to medication reconciliation. Female gender, number of treatments >7, admission from emergency department and during night or weekend were significantly associated with a higher risk of MEs. Risk score was constructed by attributing 1 or 2 points to these variables. Patients with a score  $\geq 3$  (OR [95% CI] 3.10 [1.15-8.37]) out of 5 (OR [95% CI] 8.11 [2.89-22.78]) were considered at high risk of MEs.

**Conclusions:** Risk factors identified in our study may help prioritising patients admitted in internal medicine units who may benefit the most from medication reconciliation (ClinicalTrials.gov number NCT03422484).

## 1 | INTRODUCTION

During hospitalisation, the transfers of patients from one care area to another are a source of medication errors (MEs).<sup>1</sup> MEs correspond to unintentional discrepancies between the medications the patient

is actually taking and current prescription order. ME may have some important clinical and economic consequences<sup>2</sup> and are often related to incomplete or misleading medication information at transition points in patients care.<sup>3</sup> A systematic review revealed that up to two-thirds of medication histories contain at least one error.<sup>4</sup> The

proportion of ME ranges from under 10% to over 60% at admission of hospitalisation, because of heterogeneous studies in terms of populations, definitions and methodology.<sup>5</sup>

To improve medication safety and decrease MEs rate, several institutions have recommended to develop medication reconciliation at all transition points such as admission, transfer and discharge.<sup>2,6-8</sup> Medication reconciliation is the process that compares a patient's medication order to all medications that the patient has been taking and should take at admission, transfer and discharge of hospitalisation.<sup>9</sup> Pharmacists are qualified to determine medication history and medication reconciliation.<sup>10-12</sup>

Yet, medication reconciliation process is very time consuming with an average of 30 minutes per patient.<sup>9</sup> Review of all inpatients within 24 hours of admissions is therefore very difficult, if not impossible. Targeting "high-risk situations" and "high-risk patients" seems crucial to detect ME related to medication reconciliation and prevent harm. Mean number of medications and age have been reported to be risk factors for ME.<sup>13,14</sup> Internal medicine units include mostly elderly patients with numerous comorbidities and subsequent poly-pharmacy, with a high risk of MEs and safety issues.<sup>15</sup> Therefore, evaluating specific risk factors and consequences of MEs in populations from internal medicine units, using a validated medication reconciliation process, seems of utmost importance. Consequently, the aim of our study was to develop a score to identify patients at higher risk of ME related to medication reconciliation in a specific population from internal medicine unit.

## 2 | METHODS

### 2.1 | Design and population

We conducted a prospective observational study from 2012 to 2016 in an internal medicine unit of an University Hospital, France. We included prospectively and consecutively all patients aged above 18 years old who were admitted to the department during the study period, hospitalised for at least 24 hours and benefited from medication reconciliation by a clinical pharmacist (Figure 1).

### 2.2 | Medication reconciliation process

At admission, clinical pharmaceutical team (senior pharmacist or resident or pharmacy students), conducted the medication reconciliation process within 24 hours of admission or on the first working day following the admission in case of admission during week-ends according to the availability of the pharmacist team. The medication reconciliation process was conducted according to a validated protocol.<sup>9</sup> The first step consists of getting the Best Possible Medication History (BPMH), defined as the most comprehensive list of all medications taken by the patient. The BPMH has to be based on at least three sources of information. The different types of sources that may be used were a detailed and structured patient or family interview,

#### What's known

- Hospitalisation of patients from one care area to another are a source of medication errors.
- Medication errors are often related to incomplete or misleading medication information.
- Medication reconciliation interventions by pharmacist are an effective strategy to reduce medication error, but is very time consuming and targeting "high-risk patients" seems crucial.

#### What's new

- In this study, we validated a risk score for detection of medication error to improve human resource management for pharmacy activities and detected most at risk patients.
- About 40% of patient in medicine unit are at risk of medication error at hospital admission.
- Clinical pharmacy team in medicine unit improved clinical practice.

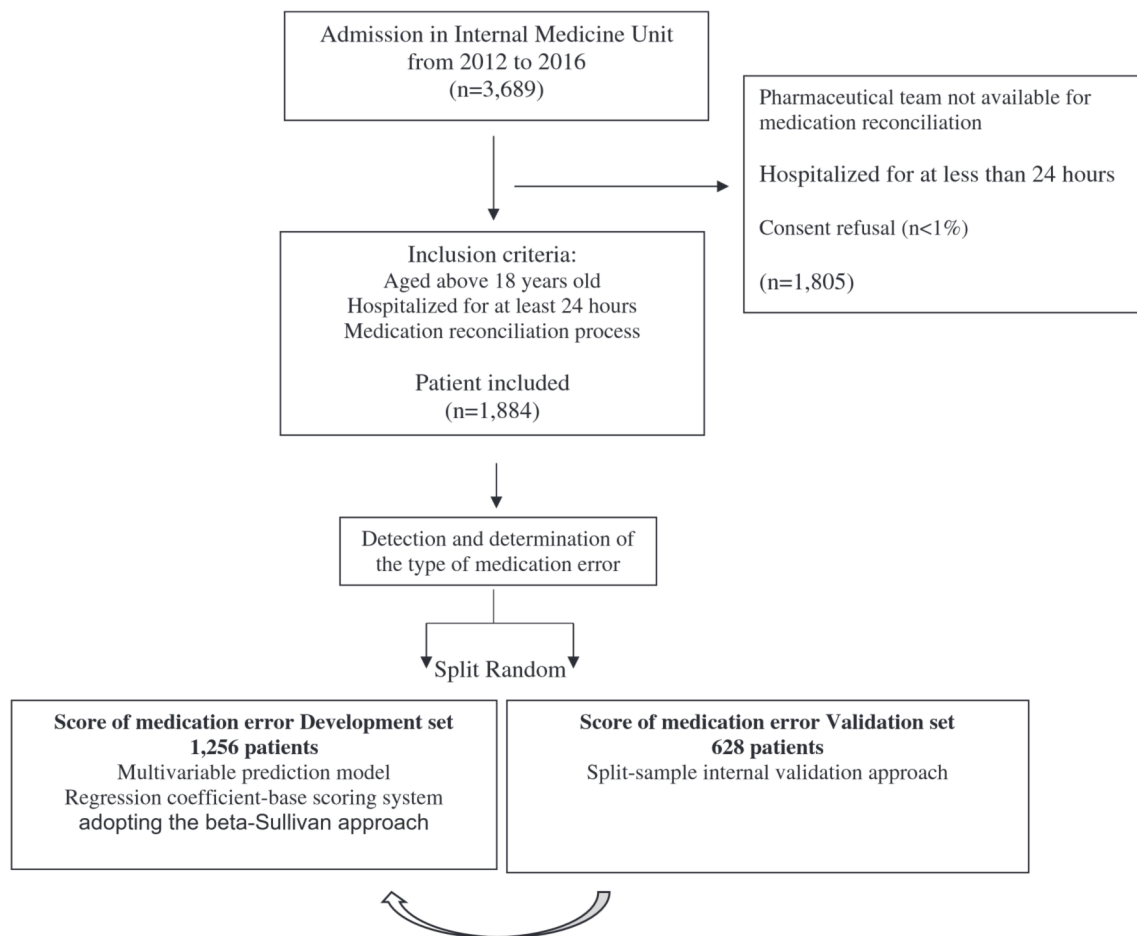
medication prescription, medical record, contact with community pharmacy and general practitioner or nurse.

The second step consists of comparing the BPMH with admission prescription. Any medication difference between BPMH and hospitalisation prescription during medication reconciliation was considered to be a medication discrepancy (MD). Pharmacists and physicians discussed each MD to determine whether it was intentional or unintentional. In agreement with the prescriber, when an unintended medication discrepancy was detected, it was considered a ME.

### 2.3 | Data collected

Demographic, clinical and hospitalisation admission data were collected for each patient. For each medication, we recorded its name, dosage, dosage forms and frequency of administration. For each ME related to medication reconciliation, we collected the type of ME (omission, incorrect dose, name medication confusion, incorrect frequency and unintended added medication) and the drug classes (according to anatomical therapeutic chemical classification system). The potential clinical impact of MEs were evaluated in patients whose errors required correction by physician. Some MEs have not been corrected by physician, because they were not clinically relevant, for example, patients were receiving proton pump inhibitor, vitamin or iron supplementation without appropriate indication. Only ME related to medication reconciliation will be analysed in this study.

The potential clinical severity of relevant MEs was determined through a consensus of an expert committee composed by two



**FIGURE 1** Flowchart of the study

pharmacists and two senior clinicians from the internal medicine department. The severity of the ME was rated based on the National Coordinating Council for Medication Error Reporting and Prevention (NCC MERP) Index for categorising MEs and adapted to get four severity categories based on the type of ME that led to this potential severity: “very serious” (errors that could lead to very serious or life-threatening consequences for the patient), “serious” (errors that may cause harm or may extend hospital stay duration), “moderate” (errors that affect patients’ quality of life) and “minor” (errors with little consequences for the patient, omission of a nonessential medication).<sup>9</sup>

## 2.4 | Statistical analysis

Clinical and biological data. Patients’ characteristics were described with proportions for categorical variables and with median and interquartile range (IQR) for quantitative variables. These characteristics were compared between ME and no-ME patients with the Student *t* test or the Mann–Whiney *U* test for continuous variables, and with chi-square or Fisher exact test for categorical variables.

Score development. In order to develop and validate the model we used the split-sample approach, which is an internal-validation

method used when only a single data set is available. The split was done at random (using a fixed seed for reproducibility purposes) to define a development data set ( $n = 1256$ ) and a validation sample ( $n = 628$ ), using the commonly used 2:1 ratio (Figure 1). We used a regression coefficient-base scoring system<sup>16</sup> adopting the beta-Sullivan (Sullivan’s scoring)<sup>17</sup> approach, where the beta coefficients are divided by the smallest absolute value of regression coefficient and rounded to the nearest integer. Complete case analysis was performed.

Relation between variables and risk of MEs related to medication reconciliation were analysed using logistic regression among the development population. We first performed a univariate analysis. Next, each variable with a *p* value below the threshold of 0.20 was included in the multivariable stepwise logistic regression model. The threshold to stay in the model was set at significance  $P \leq .05$ . We used the variables retained in the final model to construct the risk score. For all variables retained, the beta coefficients are divided by the smallest absolute value of regression coefficient and rounded to the nearest integer. The risk score was computed by summing the scores of individual variables. The performance of the score (the discrimination) was demonstrated in the validation sample by assigning their score to each individuals and using the receiver operator characteristic (ROC) curve to calculate the area under the curve (AuC),

**TABLE 1** Baseline characteristics of study patients

	Development population				Validation population			
	Total (n = 1256)	No Medication Errors (n = 1021)	Medication Errors (n = 235)	P value	Total (n = 628)	No Medication Errors (n = 495)	Medication Errors (n = 133)	P value
Age, years	77 (64-85)	76 (63-85)	80 (71-86)	<.0001	77 (63-86)	76 (61-86)	79 (70-86)	.028
Sex, Male	663 (52.8%)	557 (54.5%)	106 (45.1%)	.009	322 (51.3%)	261 (52.7%)	61 (45.8%)	.159
Living area				.025				.381
Home	777 (61.9%)	651 (63.7%)	126 (53.6%)		410 (65.3%)	329 (66.5%)	81 (60.9%)	
Home with help	344 (27.4%)	268 (26.2%)	76 (32.3%)		148 (23.6%)	113 (22.8%)	35 (26.3%)	
Institution	123 (9.8%)	93 (9.1%)	30 (12.7%)		68 (10.8%)	52 (10.5%)	16 (12.0%)	
Unknown	12 (0.9%)	9 (0.8%)	3 (1.3%)		2 (0.3%)	1 (0.2%)	1 (0.8%)	
Comorbidities								
Cardiovascular disease	891 (71.0%)	709 (69.4%)	182 (77.4%)	.015	437 (69.6%)	339 (68.5%)	98 (73.7%)	.247
Diabetes	361 (28.7%)	288 (28.2%)	73 (30.1%)	.383	182 (29.0%)	135 (27.3%)	47 (35.3%)	.069
Dyslipidemia	258 (20.5%)	199 (19.5%)	59 (25.1%)	.055	135 (21.5%)	303 (19.9%)	90 (24.4%)	.567
Lung	249 (19.8%)	208 (20.4%)	41 (17.5%)	.311	132 (21.0%)	101 (20.4%)	31 (23.3%)	.465
Neurological	155 (13.3%)	120 (11.7%)	35 (14.9%)	.187	75 (11.9%)	65 (13.1%)	10 (7.5%)	.076
Psychiatric	268 (21.3%)	213 (20.8%)	55 (23.4%)	.391	111 (17.7%)	86 (17.4%)	25 (18.8%)	.702
Thyroid	145 (11.5%)	111 (10.9%)	34 (14.5%)	.120	94 (15.0%)	74 (15.0%)	20 (15.0%)	.979
Osteo-articular	198 (15.8%)	158 (15.5%)	40 (17.0%)	.558	102 (16.2%)	77 (15.6%)	25 (18.8%)	.368
Digestive	126 (10.0%)	98 (9.6%)	28 (11.9%)	.287	64 (10.2%)	49 (9.9%)	15 (11.3%)	.640
Cancer	108 (8.6%)	84 (8.2%)	24 (10.2%)	.328	45 (7.2%)	31 (6.3%)	14 (10.5%)	.090
Number of chronic diseases > 3	488 (38.9%)	375 (36.7%)	113 (48.1%)	.001	257 (40.9%)	194 (39.2%)	70 (52.6%)	.089
Medication list								
Median (IQR)	8 (5-10)	7 (5-10)	9 (6-11)	<.0001	8 (5-11)	7 (5-10)	9 (7-12)	<.0001
>7	629 (50.1%)	485 (47.5%)	144 (61.3%)	.0001	333 (53.0%)	239 (48.3%)	94 (70.7%)	<.0001
Admission from emergency unit	768 (61.2%)	596 (58.4%)	172 (73.2%)	<.0001	394 (62.7%)	289 (58.4%)	105 (79.0%)	<.0001
Admission during the night or weekend	521 (41.5%)	395 (38.7%)	126 (53.6%)	.0001	268 (42.7%)	191 (38.6%)	77 (57.9%)	<.0001
Cause of hospitalization				.216				.0004
Respiratory	200 (15.9%)	154 (15.1%)	46 (19.6%)		96 (15.3%)	72 (14.6%)	24 (18.1%)	
Cardiorespiratory	102 (8.1%)	80 (7.8%)	22 (9.4%)		45 (7.2%)	29 (5.9%)	16 (12.1%)	
Cardiovascular	60 (4.8%)	51 (5.0%)	9 (3.8%)		37 (5.9%)	24 (4.9%)	13 (9.7%)	
Metabolic	79 (6.3%)	64 (6.3%)	15 (6.3%)		50 (8.0%)	42 (8.5%)	8 (6.1%)	

(Continues)

TABLE 1 (Continued)

	Development population			Validation population			
	Total (n = 1256)	No Medication Errors (n = 1021)	Medication Errors (n = 235)	Total (n = 628)	No Medication Errors (n = 495)	Medication Errors (n = 133)	P value
Infection	97 (7.7%)	83 (8.1%)	14 (5.9%)	44 (7.0%)	28 (5.7%)	16 (12.0%)	
Hypertension	126 (10.0%)	108 (10.6%)	18 (7.6%)	57 (9.1%)	51 (10.3%)	6 (4.5%)	
Deterioration of the general status	96 (4.8%)	72 (7.1%)	24 (10.2%)	54 (8.6%)	41 (8.3%)	13 (9.7%)	
Fall	101 (8.0%)	79 (7.8%)	22 (9.3%)	49 (7.8%)	39 (7.8%)	10 (5.5%)	
Others	395 (31.5%)	330 (32.3%)	65 (27.6%)	196 (31.2%)	169 (34.1%)	27 (20.3%)	

Note: Data are median (IQR) or n (%).

which reflects the performance in discrimination (of the score). Identically the ROC curve was used to determine the threshold of the score using the Youden index.

Statistical analyses were performed at the conventional two-tailed  $\alpha$  level of 0.05 using SAS version 9.1 (SAS Institute, Cary, North Carolina).

## 2.5 | Ethical considerations

All procedures performed in this study involving human participants were in accordance with the 1964 Helsinki declaration and its later amendments. Oral consent was obtained before inclusion in the study. The study protocol was approved by the Institutional Review Board of our university hospital (Comité Local d’Ethique Recherche, n°2018\_IRB-MTP\_02-03) and was registered on ClinicalTrials.gov (NCT03422484).

## 3 | RESULTS

### 3.1 | Patients’ characteristics

Among the 3689 patients who hospitalised in the internal medicine unit during the study period, 1884 patients (51.1%) were included in the study and split into two subsets, a development set (n = 1256) and a validation set (n = 628). Characteristics of both study populations are shown in Table 1.

The development population (n = 1256 patients) included 663 males (52.8%). The median age was 77 (IQR 64-85). In total, 62% of patients lived at home without any help and 37% benefited from help or lived in an institution. Patients mainly suffered from cardiovascular diseases (71%), diabetes mellitus (28.7%), dyslipidemia (20.5%) and lung (19.8%) or psychiatric (21.3%). The majority of hospitalisations were unplanned with patients mostly coming from emergency department (61.2%). Moreover, 41.5% of hospitalisations occurred during the night or week-end (Table 1). Among those patients, 235 had ME (18.7%) related to medication reconciliation.

The validation population had very similar demographic and clinical characteristics (Table 1).

### 3.2 | Characteristics of medication errors related to medication reconciliation

Characteristics of medication errors are described in Table 2. The development set included 235 (18.7%) patients with at least one medication error and a total of 467 MEs. The most common type of ME was omissions (56.5%). The major medications involved in ME were medications of cardiovascular system (26.1%), nervous system (22.7%) and alimentary tract and metabolism (16.1%). Among the 235 patients with at least one ME, the potential clinical impact of the ME could be determined by the expert panel in 194 patients

	Number (%)	Development population	Validation population
Medications involved (ATC level 1)	740	467	273
Alimentary tract and metabolism	120 (16.2%)	75 (16.1%)	45 (16.5%)
Blood and blood forming organ	50 (6.8%)	29 (6.1%)	21 (7.7%)
Cardiovascular system	179 (24.2%)	122 (26.1%)	57 (20.9%)
Genito-urinary system and sex hormones	26 (3.5%)	17 (3.6%)	9 (3.3%)
Nervous system	147 (19.9%)	106 (22.7%)	41 (15.0%)
Respiratory system	27 (3.6%)	16 (3.4%)	11 (4.0%)
Sensory organs	37 (5.0%)	22 (4.7%)	15 (5.5%)
Others	53 (7.2%)	28 (6.0%)	25 (9.2%)
Missing data	101 (13.6%)	52 (11.1%)	49 (17.9%)
Type of Medication Error	740	467	273
Omission	408 (55.1%)	264 (56.5%)	142 (52.7%)
Added medication	38 (5.1%)	28 (6.0%)	10 (3.7%)
Wrong dose	142 (19.2%)	86 (18.4%)	56 (20.5%)
Wrong frequency	10 (1.4%)	8 (1.7%)	2 (0.7%)
Name medication confusion	15 (2.0%)	10 (2.1%)	5 (1.8%)
Missing data	127 (17.2%)	71 (15.2%)	56 (20.5%)
Patient with medication error	368	235	133
Potential clinical impact evaluation	304	194	110
Minor	118 (38.8%)	79 (40.7%)	39 (35.5%)
Moderate	117 (38.5%)	79 (40.7%)	38 (34.5%)
Serious/very serious	69 (22.7%)	36 (18.6%)	33 (30.0%)

**TABLE 2** Characteristics of Medication errors

Note: Data are n (%); ATC, Anatomical Therapeutic Chemical classification system.

**TABLE 3** Risk factors of MEs: univariate and multivariable analyses in the development population (n = 1256)

	Risk factor of Medication errors					
	Univariate analysis			Multivariable analysis		
	OR (95% CI)	P	Beta (SE)	OR (95% CI)	P	
Age > 75 y old	1.7 (1.2-2.2)	.0008				
Gender (female)	1.4 (1.1-2.0)	.01	0.33 (0.15)	1.4 (1.0-1.9)	.03	
Cardiovascular disease	1.5 (1.1-2.1)	.02				
High blood pressure	1.5 (1.1-2.0)	.01				
Dyslipidemia	1.4 (1.0-1.9)	.06				
Thyroid diseases	1.4 (0.9-2.1)	.10				
Neurologic diseases	1.3 (0.9-2.0)	.20				
Psychiatric diseases	1.2 (0.8-1.6)	.39				
Chronic diseases > 3	1.6 (1.2-2.1)	.001				
Number of treatments > 7	1.7 (1.3-2.3)	.0002	0.56 (0.15)	1.7 (1.3-2.3)	.001	
Admission from Emergency Department	2.0 (1.4-2.7)	<.0001	0.47 (0.17)	1.6 (1.1-2.3)	.007	
Admission during night or Week End	1.8 (1.4-2.5)	<.0001	0.44 (0.16)	1.5 (1.1-2.1)	.005	
Living area		.01				
Home vs institution	0.6 (0.4-0.9)					
Home with help vs institution	0.9 (0.5-1.4)					

Abbreviations: CI, confidence intervals; OR, odds ratio; SE standard error.

**TABLE 4** Full diagnostic (logistic) model and risk score construction

	Beta coefficient	Corrected Beta coefficient	Points attributed to construct the risk score
Gender (female)	0.34	1	1
Number of treatments > 7	0.56	1.65	2
Admission from emergency department	0.48	1.43	1
Admission during night or week end	0.44	1.30	1

**TABLE 5** Distribution and odds ratios for each medication error risk score

Risk score	Development population		Validation population	
	N (%)	Odds ratios [95% CI]	N (%)	Odds ratios [95% CI]
0	97 (7.7)	1	50 (8.0)	1
1	253 (20.1)	0.95 [0.46-1.95]	116 (18.5)	1.23 [0.38-3.95]
2	403 (32.1)	1.15 [0.60-2.19]	189 (30.1)	1.77 [0.63-4.92]
3	329 (26.2)	2.09 [1.12-3.90]	167 (26.6)	3.10 [1.15-8.37]
4	147 (11.7)	2.18 [1.15-4.16]	89 (14.2)	5.60 [2.07-15.15]
5	27 (2.1)	5.08 [2.59-9.97]	17 (2.7)	8.11 [2.89-22.78]

Note: Risk score = 1 × female gender + 1 × admission from emergency department + 1 × admission during night or Week End) + 2 × number of treatments > 7.

Abbreviation: CI, confidence interval.

(83%). Among them, MEs were rated as serious or very serious errors in 18.6% of patients, moderate in 40.7% of patients and minor in 40.7%.

In the validation set, proportion and characteristics of MEs were very similar (Table 2). The potential clinical impact of the MEs could be evaluated in 110 patients (83%), and was rated as serious or very serious, moderate and minor in respectively 30.0%, 34.5% and 35.5% of patients.

### 3.3 | Risk factors of ME and risk score development

Risk factors of MEs in the development population are described in Table 3. Female gender, the number of treatments (greater than 7), admission from the emergency department and admission during the night or weekend were significantly associated with a higher risk of ME in multivariable analysis. The risk score of ME at admission was constructed by attributing 1 or 2 point to each of these four variables as described in Table 4. It, therefore, ranges from 0 to 5. The ability of the risk score to predict ME related to medication reconciliation was assessed by the area under the curve (AUC) of the Receiver Operation Characteristic (ROC) curve and was equal to 0.63 (95% CI 0.63-0.67) in the development population. The threshold of the score was set to 2.5 meaning that patients with a score above of or equal to 3 were considered at high risk of ME. Table 5 shows the proportion of patients and the risk of medication error for each value of the score, in both populations.

### 3.4 | Validation of the risk score

The AUC, assessing the ability of the risk score to predict ME was 0.681 (95% CI 0.681-0.731) in the validation population (Figure A1). Specificity was 53% and sensitivity was 74%, with 99 individuals (74.4%) who were adequately classified as being at risk of ME out of 133 patients with ME. The score therefore failed to detect 34 individuals with MEs. Of the 33 patients with serious MEs identified in the validation population, 25 (76%) were detected by the score.

## 4 | DISCUSSION

In the present study, we developed a risk score of MEs related to medication reconciliation that can be used in clinical practice to prioritise pharmacist interventions and improve management of health care through optimised use of resources. This score was based on the independent risk factors of MEs identified in a large population of patients admitted to an internal medicine department.

We found that about 1 out of five patients have at least one MEs at admission of hospitalisation. Ranging of MEs widely differs between studies reporting MEs from 10% to 60% of patients at admission of hospitalisation,<sup>4,13,18-21</sup> probably because of differences in study design and population.<sup>4,22,23</sup> Thereby, depending on the type of care unit and on the inclusion criteria, the incidence of MEs may vary from



17.7% in a cardiology unit<sup>20</sup> to 19.5%<sup>9</sup> in an endocrinology unit, with studies having broad inclusion criteria, and from 33.2% to 64.5% in internal medicine units with studies having more specific inclusion criteria (age > 65 years, ≥5 drugs, admission from the emergency department). In our study, we chose to have broad inclusion criteria to have a representative population of internal medicine units in a real-life condition of medical care without any selection criterion. In total, 22.7% (69/304) patients with ME had potentially serious or very serious MEs at admission. It is difficult to compare our results because of different methodologies between studies.<sup>24</sup> However, 12.8% to 66.2% of MEs intercepted by reconciliation could cause potential damage to patients.<sup>25</sup> Nevertheless, the proportion of potentially serious MEs observed in our study was higher than in other comparable studies in internal medicine and cardiology units<sup>15,20,26</sup> and lower than in endocrinology unit with diabetic patients.<sup>5,9</sup> These differences in incidence of serious MEs may be because of the profile of patients, number and type of chronic diseases or medications.

We highlighted four risk factors of MEs at admission of hospitalisation: female gender, number of treatments > 7, admission from emergency department and admission during night or weekend. The number of medications as well as the type and time of admission had already been described as significant predictors of MEs.<sup>9,13,14,27</sup> We developed a risk score based on these risk factors to prioritise interventions aiming at detecting and correcting MEs. Indeed, clinical pharmacists cannot conduct medication reconciliation in all patients, and prioritisation of patients is crucial in daily clinical practice to manage adequately patients at higher risk of MEs. Our score allows clinical pharmacists to focus on the patients most at risk of ME. It has changed our clinical practices by improving clinical pharmacist efficiency in errors detection and patient safety. In our unit, about 40% of patients were considered at high risk with a score above 3. Nevertheless, another threshold may be used in other internal medicine units depending on the human resources and patients characteristics, given that patients with a higher score have a higher risk of MEs. Several studies have tried to develop a procedure of prioritisation.<sup>28,29</sup> Statistical models have been developed to predict adverse drug event including MEs, which is a complex endeavour.<sup>30</sup> Our study used a methodology comparable to other predictive score studies presented in the systematic review of Falconer et al with a prospective design and consecutive inclusion, a sample size of more than a thousand patients, a validated method to measure outcome and internal validation.<sup>30</sup> However, compared with these studies we focused on MEs detection in a specific population.

Our score is based on simple variables quickly available in the medical record and can be easily and quickly calculated. The decision to use the Sullivan's scoring was taken because it yields a score that is easy to use and implement in clinical practice, without loss of discrimination power, despite the loss of predictive power (we cannot with this score attribute an individual probability of ME). Thereby, the score we have developed and the risk factors we have highlighted cannot exclude all patients without errors but may target the most at risk patients. Thus, medication reconciliation must be carried out on as many patients as possible. A multidisciplinary team seems essential to manage patients with complex diseases and

comorbidities. The clinical pharmacist should become a full member of such a multidisciplinary team including internists, to provide integrated care.

To our knowledge, this is the first study evaluating the incidence, severity and developing a risk score of MEs at admission in an internal medicine unit. In addition, despite our monocentric design, our population seems to be representative of an internal medicine unit population with chronic diseases, a large number of treatments and an advanced age. Our population also included a large proportion of admissions from emergency unit and during the night or weekend as described in many studies.<sup>15,31,32</sup>

## 4.1 | Limitations

However, our study has some limitations, we only analysed ME related to medication reconciliation, its observational design, without evaluation of the clinical use of the ME risk score on improved detection and safety of patient. In addition, we did not conduct an external validation of the score.

## 5 | CONCLUSIONS

We developed and validated a risk score for detection of MEs related to medication reconciliation to improve human resource management for clinical pharmacy activities and detected most at risk patients. Rapid detection and correction of MEs are vital to ensure patient safety. Integration of a clinical pharmacy team in internal medicine unit and the implementation of medication reconciliation process have secured the admission prescription and improved clinical practice. Thereby, our methodology can be used in other internal medicine units to improve quality and safety of medical care.

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## DISCLOSURE

The authors have declared no conflicts of interest for this article.

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APPENDIX

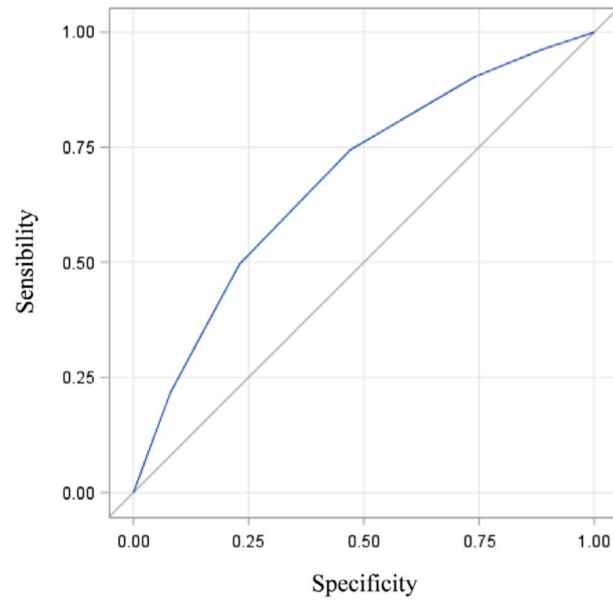


FIGURE A1 ROC curve assessing the ability of the risk score to predict medication error (Area Under the Curve 0.681)